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(71) Applicants *(for all designated States except US)*: BUDAPESTI MŰSZAKI EGYETEM [HU/HU]; Műegyetem rkp.3, H-Budapest XI (HU). LABOR MŰSZERIPARI MŰVEK [HU/HU]; Rudas László u. 44, H-Esztergom (HU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : BÉKÉS, Ferenc [HU/HU]; Népstadion u. 16, H-Budapest XIV (HU). HIDVÉGI, Máté [HU/HU]; Baross u. 64/a, H-Budapest XX (HU). KEMÉNY, Gábor [HU/HU]; Érdi út 10/a, H-Budapest XI (HU). POKORNY, Tibor [HU/HU]; Baross u. 18, H-Budapest IV (HU). LÁSZTITY, Radomir [HU/HU]; Lágymányosi ut 22, H-Budapest XI (HU). KÓS, Iván [HU/HU]; Ozgida u. 20/b, H-Budapest II (HU). FÓRIZS, Katalin [HU/HU]; Mexikói ut 51, H-Budapest XIV (HU).

(74) Agent: PATENTBUREAU DANUBIA; Bajcsy Zsilinszky ut 16, P.O. Box 198, H-1368 Budapest (HU).

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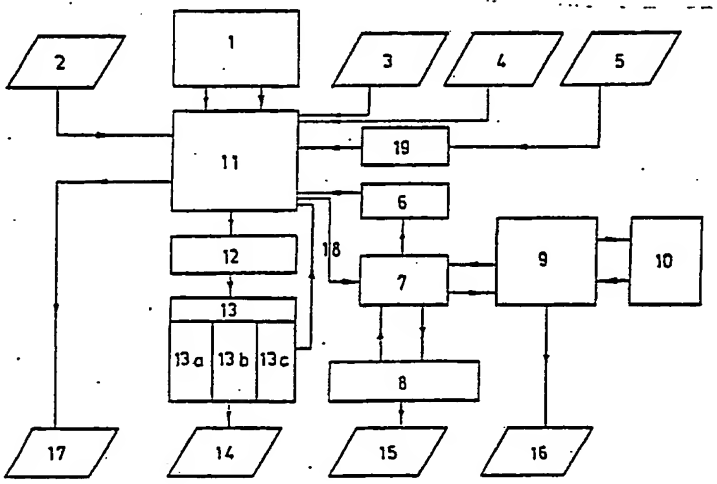
(57) Abstract



In the practice of the feeding that food admixed from starting substances possessing different parameters concerning the inner contents has been considered optimal which is of the minimum specific costs between appropriate composition limits on the basis of certain theoretical considerations and practical experiences. In the complete course of the farm animal keeping, particularly in the case of monogastric animals, the optimum fodder forming is not the cheapest fodder but that fodder possessing the possible maximum biological value for a minimum price. According to the invention on the basis of the established demand data of the farm animals the optimum quantity and ratio of the essential amino acids being in the fodder mixture and to be attained for the animals have to be found so that at the same time the other parameters concerning the inner contents of the traditional fodder optimization have to be taken into account, too. One difficulty of a quick establishment of the optimum fodder composition is the fact that a laboratory determination of the composition of the fodder basic substances is slow and complicated, often it is not possible due to the conditions in the mixing plants, according to the invention such an apparatus is suggested which on the basis of the near infrared measurements directly determines important data concerning the inner contents, corrects the data stored in the data bank with these data after an appropriate check and setting from these data determines the optimum composition.

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PROCESS AND APPARATUS FOR FORMING THE OPTIMUM MIXING RATIOS OF THE COMPONENTS OF FEEDING STUFFS, PARTICULARLY FODDERS ACCORDING TO THE BIOLOGICAL VALUE AND/OR PRICE

Subject of the Invention

The invention relates to a process and apparatus with the help of which the necessary starting substances or those in stock can be examined according to the food-value or other composition or quality parameters and on the basis of the test results, the earlier measurement data appropriately stored in the apparatus or literature data an optimum mixing ratio can be established at which the quantity and ratio of the essential amino acids is the most advantageous if at the same time the price of the mixed fodder prepared accordingly and the other prescribed parameters concerning the inner contents, too, are maintained at an advantageous value.

At the demand for the essential amino acid and the range of the parameters concerning the inner contents the data of the relating species of animals characterizing the age, genus, method of keeping and other status /e.g. gestation, disease and so on/ are taken into account.

Theoretical Background

In order to determine the optimum mixing ratio of the fodder mixtures the values of the starting substances concerning the inner contents have to be established or estimated. The estimation is possible with the help of the data bank collected from the literature but it is qualified as estimation, too, if only seasonal data are taken into consideration or possibly data chracterizing the soil, place and method of production.

The traditional wet-chemical methods use the chemical development of the samples and taking into account the usual laboratory organization, the result can be given only after some hours or days of transit time. The non-destructive physico-chemical methods becoming more and more widespread recently are generally based on the close connection between a value concerning the inner contents and a physico--chemically measurable feature of the substance. Among these the interaction between the electromagnetic radiation and the substance plays an outstanding role, particularly in the infrared range and within that in the near infrared range. Due to Prof. Norris' pioneer work /USDA, Beltsville, MD, USA/ the near infrared reflection and transmission spectrometry, respectively, became an analytical method already widely proved today in the analysis of agricultural samples. Calibrating on the basis of the laboratory measurements the modern near infrared reflection /NIR/ analysers attain a precision and reproducibility identical with that of the laboratory measurements at the most important components of numerous products.

Among appropriate apparatus constructions an interference-filter composition is disclosed in Britain patent specification 1, 432,634, U.S. patent specification 3,861,788 as well as U.S. patent specification 4,082,464.

It is characteristic for these apparatuses that with the help of a pre-adjusted parameter set the composition values are provided from the measured product in some points, or on the basis of the reflectometer value spectrum adopted in the complete spectrum range on a suitable periphery /screen, printer, hard copy output/. The different claims relate to the optical arrangements, the number of the filters and their

setting in relation to the sample. In the knowledge of the plenty of literature on the NIR application technique it can be stated that a wide-band /1-2.5 /um/ NIR spectrometer is suitable for a rapid and reliable measurement of most of the parameters concerning the inner contents and being important from the fodder aspect of mixed fodders as well as concerning the basic substances of the fodder production after an appropriate calibration.

It can be considered proved that the NIR spectrum correlates to the moisture, fat and protein contents of the different products, at fodders a multiple correlation coefficient higher than R = 0.94 can be attained for the protein, ADF /acid detergent fibre/, NDF /neutral detergent fibre/, lignine, cellulose, and extract content /J.S. Shenk, M.R. Hoover, M.O. Westerhaus: Maryland Nutrition Conference, March 15-16, 1979 p. 100/. Ca, P, Ca/P, too, can be determined by correlation higher than 0.84.

From the NIR spectrum conclusions can be drawn for the digestibility being very important for the feeding. The disappearance of dry matter, digestibility and weight gain were measured in vitro appropriately by R = 0.89, 0.96 and 0.92 correlation, respectively.

Calibration can be carried out with the spectral data on the basis of a sample selected from the basic substances as well as the mixtures thereof used for feeding and the number of which corresponds to aspects of statistics, the composition of which is known or which possesses known in vitro and in vivo measurement data what generally means a multiple linear regression mathematical process.

Since the decisive majority of the most important values concerning the inner contents taken

into account from the feeding aspect can be measured rapidly by the NIR spectrometry besides a suitable calibration, it seems to be suitable to use such a measuring system as integral part of an apparatus developed for the optimization of the fodder.

It is an econometric statement that the expenses spent for fodders /the state purchase prices/ amount to two thirds of the production costs of the animal husbandry. This fact represents a challenge for the rationalization of the animal husbandry and it became extremely urgent particularly nowadays since the lack of protein is not an isolated phenomenon any more, but a crisis increasing in universal dimensions. On the field of the animal husbandry the protein problem appears in two ways at the same time: on the one hand in form of an increasing meat demand of a mankind increasing in number, on the other hand in a more and more reduced quantity of protein-carrying fodder components. At present it deems that the biggest limit of the increase of the mankind is the reduced quantity of the feed protein as well as the biggest limit of the increase of the quantity of the feed protein is the limited mass of the fodder proteins. Therefore it can be stated that the economy with the fodder proteins is of strategic importance.

The problem on the level of economy can be drafted as follows: meat produced as cheap as possible and other animal products, respectively, that is the maximum ofthe quotient of the meat production and the production costs is the aim.

These statements are obviously evident, in practice, however, as we will see later, they have not been manifested yet.

The mixture fodders appear in two ways on the market: on the one hand - from the fodder produc-

ing firms - as final products, on the other hand as raw materials for the stock-breeding firms.

As final product they have to bring economical profit what means their preparation directed by the aim of minimum production costs. Therefore they cannot mean a raw material ensuring an optimum biological production for the animal husbandry, neither in spite of the fact that the minimization of the production costs is performed by taking into consideration certain main demand data of the farm animals to be fed as restricting parameters. If both the fodder production and the animal husbandry are treated as one system, the conclusion is unambiguous that in the course of the fodder production not the minimum of the production costs but the maximum of the quotient of the prime cost of the fodder and the biological production has to be considereed the aim.

At present this fact has not been recognized and a system suitable for the realization of this conception has not been described, respectively.

In the international practice the prime cost minimizing, so-called "least cost" method is used /Becher, A.-Prinz, W. /1963/: Kraftfutt. 46, 3.; Groote, G. et al. /1965/: Rev.Agr.Brux. 17, 12.; Dent, J.B. /Casey, H. /1967/: Linear Programming and Animal Nutrition, London.; Inglett, G.E. et al. /1969/: Cer. Sci Today 14, 69.; Cavins, J.F., et al. /1972/: Fd. Technol. June. p. 46; Davies, Y. et al. /1973/: Poult. Sci. 52, 102; Rabold, J. /1977/: Mühle Mischfutt. 114, 577.; Wadsworth, J.I. et al. /1979/: Cer. Fds. World 24, 274; Jones, G.M. et al. /1980/: J. Dairy Sci. 63, 495/.

For the practical use of this method numerous systems were developed, among others the "Feed Information Service" program packet of the NCR Corp. provided with an appropriate program the system TRS-80 Model II

of the firm Radio Shack, the "Home Computer" of Texas Instruments, the mini computers of IBM and Burroughs Corp., the system EAL 3020 of the Eletronic Associates Ltd., the apparatus of the firm Commodore International, the small-dimension target systems of the Cornell University and the Iowa State University, the extended "Agricultural Computer Network" of the Nebraska University, the "Today's Electronic Planning" systems of the Michigan State University. For a smaller field of activity still system "Computer Decision Aids" of the Minnesota State University as well as the systems of the University of Delaware and the University of California are operated. In a newer improved form the system "Fast Agricultural Communication Terminal System" of the Purdue University /Feedstuffs, 1979, May-June, p. 1/ operates.

The common feature of the above systems is that the optimization aims at the price minimitation, one operates besides keeping the parameters concerning the inner contents between limits exclusively on the basis of literature or earlier laboratory measurement data.

From the point of view of trophology the nutritive value of the foodstuffs is determined by the protein introduced bythe food and the amino acid composition thereof, respectively. For the setting up of the body-proteins of the human and animal organism different amino acids are necessary in a determined quantity and ratio. Since the proteins introduced bythe food do not include the amino acids in the necessary ratio and not the complete quantity of the introduced amino acids can be used for the setting up of the own proteins, respectively, at the examination of the biological value of the protein sources the

problem cannot be reduced to a comparison of the relations of the introduced gross amino acid composition but the production of the utilized part has to be considered as basis of the value measurement. Under the biological value of a protein source after all the relation between the concentration of the essential amino acids to be found in the utilizable part thereof as well as the specific essential amino acid demand of the living being consuming it is to be understood. There is an optimum ratio of the amino acids for every living being. Any deviation from this ratio leads to a decrease of the biological value /Kofrányi, E. /1973/: Nutr. Rep. Int. 7, 45/.

The biological value can be determined fundamentally by two methods: by foddering tests and on the basis of parameters concerning the inner contents, respectively, and by calculation. Concerning the fact that the foddering tests supply a reliable result only in the case if a high number of individuals, many parallel groups take part in the tests as well as since the measurements demand extremely high costs and time /e.g. for the testing of one protein sample eight people, four parallel measurements, 30,000 $ and sixty days are necessary/, nowadays increased interest is shown for rapid and cheap chemical methods /Bodwell, C.E. /1977/: Nutr, Rep. Int. 16, 163/.

One very important peculiarity of the biological value is that it is not additive, that is in the case of mixtures the biological value of the product is not identical with the linear combination of the biological value of the components. This very important property of the biological value is characterized by the fdlowing chemical index in a possible form of the invention:

wherein X_j is the wanted vector of the components
m is the number of the components to be admixed
n is the number of the essential amino acids to be taken into account in the case of the given farm animal
$A_{i,j}$ is the i-amino acid taken into account of the j-component to be admixed
$a_{i,r}$ is the biological demand of the given farm animal from the essential i-amino acid
α_i is the weighting factor established in the course of the biological tests.

This connection cannot be considered a purely chemical index, since it includes the data of biological tests in its nominator.

The aim of the invention is to elaborate a system which can measure as many important parameters concerning the inner contents of as wide a scope of products as possible rapidly and directly in contradiction to the optimizing apparatusses known until now. Furthermore it is the aim to establish such an adaptive system which carries out the optimization and the fodder-advising on the basis of an extended data bank, these data can be written one above the other cancelling the latter, with the measurement results, the external measurement - e.g. periodical - data besides appropriate control, the data base can be amplified in every respect, the measurement apparatus forming a part of the system can be expanded by new methods. And it was the aim to approach the optimization of the mixed

fodder recipes in a new way by developing a value measuring process suitable for the characterization of the biological value of the proteins and taking into account the specifical amino acid demand of the consumers, defining the maximization of the production of an animal product produced with as lower costs as possible as objective.

Specification of the System

Thus the invention relates to an apparatus suitable for the optimum forming of feeding stuffs, particularly fodder mixtures which includes an optical unit suitable for the measurement of the near infrared diffuse reflection spectrum or spectrum detail, the control electronic unit thereof, the reflection spectrum signal processing and storing equipment thereof and a computer part suitable for the transformation of the spectrum and then the calculation of the parameters concerning the inner contants.

The results of the infrared measurements get to such a field of operation to which the optimizing system can access. The unit performing the optimization is provided with such an operative memory field or background memory suitable for data storage, which contains as many values concerning the inner contents of the products as possible applicable for the mixed fodders, the essential amino acid demand data of the inditidual farm animals, the demand data provided as lower and/or upper limit of thedemand data of other parameters concerning the inner contents or according to the ratios thereof, the quantity of the reserve at disposal or the utilizable reserves or the ratios thereof.

For feeding the data necessary for the optimization the apparatus is provided with data supplying means, the optimum composition, however, obtained

as result can be dispalyed and recorded, respectively, on data output devices connected to the apparatus, too.

Figure 1 shows the block-scheme of an advantageous form of the invention. Data bank 1 can be placed on a floppy disk as a whole or broken down according to species of animals, to this floppy disk a data bank operator 11 can access and feed data if desired. 2 reserves an optimization demand data, 3 local or seasonal composition data, laboratory measuring results, 4 biological value demand data and 5 foddering test data serve as input data from the point of view of the system. The data bank operator unit directly accesses the 6 infrared composition operation field and is directly connected to the 7 near infrared analyzer control unit. The latter controls the operation ofthe 8 near infrared analyser but through this the 9 infrared developing system and the background store unit 10 thereof are joined.

The data bank operator establishes the operation field of the data used for 12 optimization. A 13 optimization part accesses the latter operation field.

Example 1

Fodder recipe optimization supported by a foddering test:

As disclosed in the description, according to claim 10, the /starting, raising, finishing/ optimization of the NRC /National Research Cuouncil/ recipes used on the broiler farm of the Gödöllő Research Institute for breeding Small Animals was carried out.

According to the result of foddering tests - carried out with several ten thousands of individuals in 1979 - the production costs for 1 kg of live weight-growth were reduced by more than 20 %.

Example 2

Optimization of human regime: optimization of bread recipes for Egypt taking into account the nutritive structure.

Data at disposal /Hussein, M.A. /1978/: Dissertation, Hungarian Academy of Sciences/ and the average annual consumption structure of two weakly fed and averagely fed classes - differing in the nutritive level - of the Egyptian population were taken as basis for the optimization of bread recipes based on wheat + + complement /naize, millet, rice, fenugreek, soya/ as described in the description - taking into account human physiological and economical points of view at the same time - which are optimal concerning the complete consumed food, that is which represent a maximum biological value.

Example 3

Completing task: completing of baking products by a protein concentrate based on beer-yeast: in the course of the completing the optimum mixing ratio of a product defined according to a concrete composition and recipe as well as a complementary substance is searched for: as disclosed in the description, on the basis of the official norm of the baking industry a beer-yeast quantity is searched for where the biological value of the completed product is maximum.

Example 4

By-Product utilization: By using the optimization of food and mixed fodder-recipes, respectively, as disclosed in the description wastes, by-products containing protein can be introduced into food for human individuals and fodder, respectively. With the help of the present process beside the maintaining - even possibly increase - of the biological value of the foodstuffs and mixed fodders, respectively, completely

valueless slaughter-house by-products often considered harmful for the environment /blood, festhers and so on/ could be introduced into different recipes and thus not only the side-products can be utilized very efficaciously but with the help of the process the producing of expensive components /fish-meal, valuable meat-part/ and the substitution thereof in a nutritive sense, too, became possible.

WHAT WE CLAIM IS:

1. A process in the course of which a representative sample is taken from the basic substances or mixtures marked for the foddering of farm animals and being at disposal on farms, the sample is ground in a suitable grinder or cut in a chipper to an appropriate size, filled into a cuvette, rendering possible an optical measurement under standard conditions, then the near infrared transmission or reflection spectrum thereof or the spectrum points thereof measurable at the wave lengths characteristic for the composition are measured, mathematical transformations can be performed on the measured spectral data, then substituting the transformed or not-transformed spectral data into a calibration equation or an equation system, the composition data of the substances which can be utilized for the admixing are obtained; the composition data obtained by the near infrared spectrometric way are used in the following for the fodder mixture optimization taking into account these substances, too, c h a r a c t e r i z e d in that a minimization of the deviation from the essential amino acid demands of the farm animals as well as the essential amino acid sample of the mixed fodder is aimed at specifically for the species, age, genus, method of keeping and physiological state so that the price of the mixed fodder, other specific demand data, antinutritive factors as well as the reserves can be taken into account.

2. A concrete measuring-optimizing system according to the process of claim 1 which uses the near infrared reflection, diffuse reflection or transmission spectrometry for the rapid measurement of the parameters concerning the inner contents, c h a r a c t e r i z e d in that the measurement data get from the near infrared analyser directly through a direct bus system or aseries channel to the apparatus performing the optimization.

3. A near infrared analyser-optimizing apparatus as claimed in claim 2, c h a r a c t e r i z e d in that the infrared analyser and the optimizing part possess a common data processing and/or common data storing part.

4. An apparatus as claimed in claim 2 or 3, c h a r a c t e r i z e d in that it compares the values of the operation field /6/ provided by the control unit /7/ with the real composition data-limits of the actually measured substance and if among those data one falls beyond these limits, a fault message is generated to the operator.

5. An apparatus as claimed in claim 4, c h a r a c t e r i z e d in that for the transfer of the operation field /6/ a control signal /8/ is generated only if all values of the operation field can be found among the value limits to be expected.

6. A device as claimed in claim 2 or 3, c h a r a c t e r i z e d in that it is capable of providing fodder optimization tasks on the basis of a data bank of an adaptive structure from the point of view of the operator, that is forming a part of the system, but can determine some important parameters concerning the inner contents if actual fodder basic substance samples are at disposal and thus is capable of improving the data base of the optimization.

7. An adaptive structure as claimed in claim 6, c h a r a c t e r i z e d in that it is capable of receiving new biological /essential amino acid/ demand data for other values concerning the inner contents, the new type of farm animal, a different method of keeping.

8. An adaptive structure as claimed in claim 6 or 7, c h a r a c t e r i z e d in that the

elaboration of the measurement technique of new products is rendered possible, too, by a developing system /9/ which on the basis of the spectra of samples taken on the near infrared spectrometer /8/ and stored in background memory /10/ and having a known composition selects optimum measurement wave lengths and appropriate mathematical spectrum transforming processes and determine the calibration constants belonging to them which can now be accessed by the spectrometer control unit /7/ or can be supplied to the operator /16/.

9. An adaptive setting up as claimed in claim 6 or 7 or 8, c h a ra c t e r i z e d in that it is capable of modifying the α_i constants of the object-function processing the results of foddering tests by the statistical evaluation system /19/.

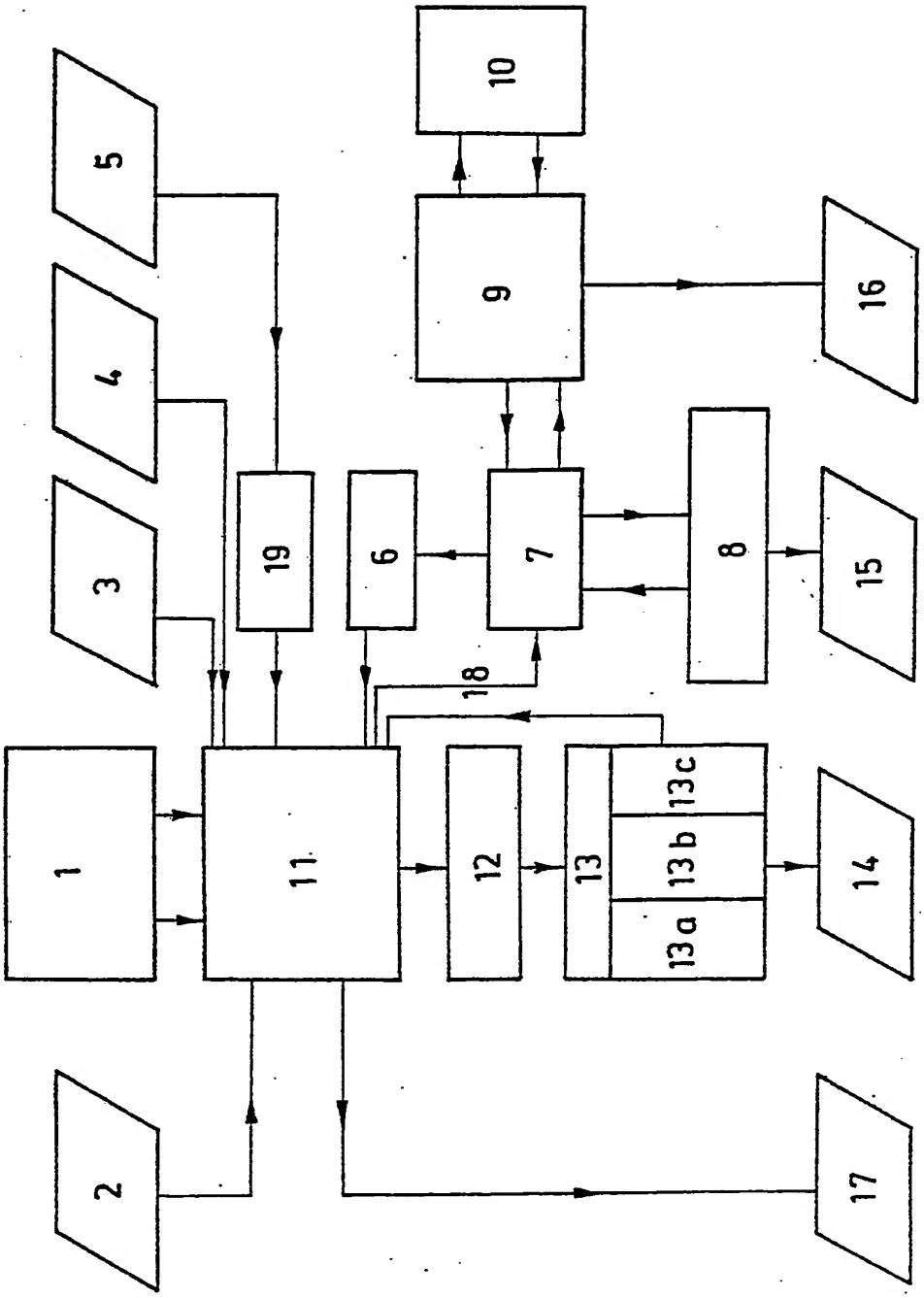
10. A process as claimed in claim 1, c h a r a c t e r i z e d in that the optimum composition is attained by maximizing the object-function defined as the quotient of the in vitro biological value and the price.

11. A process as claimed in claim 1, c h a r a c t e r i z e d in that the optimum composition is attained by maximizing the in vitro biological value object-function taking into account the price as limiting factor.

12. A process as claimed in claim 1 or 10 or 11, c h a r a c t e r i z e d in that the reserves are optimally taken into account taking into consideration the preferring factors and limiting inequalities, respectively.

13. A solution as claimed in one of claims 3, 4, 5, 6, 7, and 8, c h a r a c t e r i z e d in that the optimum composition is prepared striving for minimum production costs.

14. A process as claimed in one of claims 1, 10, 11 or 12, c h a r a c t e r i z e d in that at the establishing of the in vitro biological value any arrangement of the amino acids is used.



INTERNATIONAL SEARCH REPORT

International Application No PCT/HU82/00066

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

G01N 21/35

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC[3]	G01N 21/35, G01N 21/34

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [15] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	Selskoe khozyaistvo za rubezhom N°4, 1979, Kolos, Moscow, KH.K. Khudyakova "Otsenka kachestva kormov metodom infrakrasnoi spektroskopii", see pages 42-43	1,2,3
Y	US, A, 4040747 (Neotec Corporation), 09 August 1977 (09.08.77)	8
Y	D.I. Marnov "Balansirovanie ratsionov i kombikormov po aminokislotam", 1967, Rosselmash, Moscow, see pages 24-26, 78-79	1,2,3

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
18 February 1983 (18.02.83)	16 March 1983 (16.03.83)
International Searching Authority [1]	Signature of Authorized Officer [20]
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